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AMERICAN FERTILIZER

" That man is a benefactor to his race who makes two blades of grass to grow where but one grew before."

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Symposium on Phosphates

American Chemical Society

Abstracts of Papers presented at a joint symposium of the Division of Fertilizer Chemistry and the Division of Industrial and Engineering Chemistry, Atlantic City, N. J., September 10, 1941.

Phosphate Deposits of the World, with Special Reference to the United States

George R. Mansfield, Geological Survey, U. S. Department of the Interior

The most comprehensive study of the phosphate deposits of the world was made by the Fourteenth International Geological Congress, Madrid, 1926. The results were published in Madrid in 1928 in two quarto volumes under the title, "Les Reserves Mondiales en Phosphates," and were contributed by authorities in forty-two countries. The phosphate reserves of the world were estimated at 7,172,429,782 metric tons (known reserves of phosphate rock) and 467,585,916,000 tons (probable reserves), with large additional possible reserves not estimated. The lower limit of phosphate content considered by the congress was 5 per cent of P_2O_5. Estimates by Mansfield (1926) and Jacob (1938) placed world reserves at 16,867,000,000 and 17,464,357,000 metric tons, respectively. In their estimates just cited Mansfield allowed 6,431,000,000 metric tons for the United states and Jacob 7,370,950,000 metric tons. Congressional Committee activities in 1938 relating to supplies of domestic phosphates led Mansfield to review in the field evidence for Florida and the Western States and Whitlatch that for Tennessee. As a result of these reviews Mansfield raised the estimate for the United States to 13,507,666,000 metric tons. These figures, together with those for recently exploited apatite deposits in the U. S. S. R., raise the world's total to 24,771,166,000 metric tons, of which the U. S. has about 55 per cent. The three great phosphate-bearing regions of the world are the United States, the U. S. S. R., and North Africa. Reserves in different countries are given in tables. The principal phosphate deposits of the United States are briefly discussed and estimates of reserves are given.

Composition and Properties of Superphosphate. Chemistry of Ordinary Superphosphate Manufacture

W. L. Hill and H. L. Marshall, Bureau of Plant Industry, U. S. Department of Agriculture, Beltsville, Md.

The processes that occur when phosphate rock and sulphuric acid are mixed in the manufacture of superphosphate are (1) dissolution, (2) precipitation, and (3) volatilization. Recent research on the crystal structure of natural apatites indicates that among other elements at least portions of the Si (quartz excepted), Al, Fe, C, Mg, Mn, and Na in phosphate rock must be considered as integral parts of the apatite. It therefore becomes practical to suppose that these constituents dissolve with the phosphate and influence more or less the composition of the liquid phase during subsequent precipitation. In commercial operation the sulphate is usually precipitated as anhydrous calcium sulphate and the phosphate as monobasic phosphates, chiefly hydrated monocalcium phosphate and hydrated calcium iron and/or aluminum phosphate.

The volatilization of water during the mixing operation appears to vary widely from plant to plant. Meager data indicate volatilizations of 2.5 to 38 per cent of the water present initially. Fluorine volatilizations are, on the average by grade of rock, suprisingly uniform for grades below 74 per cent B.P.L. and uniformly lower for grades above 74 per cent

B.P.L. At the same plant, volatilizations from the same grade of rock may differ by 8 per cent or more of the total fluorine—a matter of special significance in the precise calculation of acid requirements.

Analysis of data for 40 samples of Florida land pebble and Tennessee brown rock indicates that the acid requirement of rock can be calculated with an accuracy of about 3 per cent from a knowledge of the P_2O_5, F, SO_3, and CaO contents and of the fluorine volatilizations realized by the plant.

Phosphate-Fixation in Soils and Its Practical Control

Firman E. Bear and Stephen J. Toth, New Jersey Agricultural Experiment Station

Microbiological consumption, chemical precipitation, and physico-chemical adsorption are responsible for phosphate-fixation in soils. Microbiological consumption is relatively unimportant. Fe and Al serve as precipitating agents at pH values below 5.5, Ca plays the dominant role at pH 6.5, and Mg enters the picture at 7.5. But chemical precipitation by these ions is inadequate to explain completely phosphate-fixation which, for Penn silt loam soil, may amount to 125 tons of 20 per cent superphosphate-equivalent per two million pounds of soil. In soils of such high fixing capacity, most of the phosphate is colloid-bound or saloid-bound, the former being replaceable by OH, humate, and silicate ions, and the latter by SO_4, Cl, citrate, and tartrate ions. Excessive fixation can be avoided by placing phosphate in bands, or by the use of granular forms. Heavy phosphating, required on acid potato soils, increases their exchange capacity and lowers the pH at which Fe and Al becomes soluble. As the quantity of phosphate applied is increased, because of greater agricultural intensity, a change from the shallow along-the-row method of application appears advisable to avoid position unavailability. Deep placement of most of the phosphate, below the zone affected by summer drouth, is suggested.

Evidence in Support of A New Concept as to the End Product of Superphosphate in Limed Soils

W. H. MacIntire and B. W. Hatcher, Agricultural Experiment Station, University of Tennessee

The new concept stems from some 14 years' experimentation as to chemical changes that ensue when superphosphates are mixed with calcic, magnesic, and dolomitic materials, and when ammoniated. It was demonstrated that, although a rapid conversion of water-soluble phosphates to dibasic forms is induced by admixed liming materials, the successive formation of tricalcium phosphate is exceedingly slow. The marked disparity between the relatively low citrate-insolubility that developed in mixtures of superphosphate with either limestone, dolomite, and mineral calcium silicate and high citrate-insolubility that developed in similar mixtures of calcium silicate slag of high fluoride content prompted a new explanation to account for P_2O_5 retrogradation in limed, as well as in ammoniated superphosphates. It was demonstrated that the generated tricalcium phosphate of either limed or ammoniated superphosphates reacts with component calcium fluoride to form calcium fluorphosphate $Ca_{10}F_2(PO_4)_6$, and that dicalcium and dimagnesium phosphates do not so react. The validity of the explanation as to the cause of P_2O_5 reversion was established by use of fluoride-free superphosphates and calcines in amplifying studies as to the factors of moisture, alkalinity, humidity, and temperature, and by microscopic and x-ray examinations.

The findings as to what had transpired in the mixtures then were extended to limed and phosphated soil systems used for Neubauer cultures. These cultures demonstrated a diminished utilization of P_2O_5 by the seedlings when the formation of calcium fluorphosphate had been induced either prior or subsequent to phosphate incorporation. There was no fluoride effect when the P_2O_5 was in the dibasic state. This factor was integrated with the advantage of using superphosphate and liming materials in a manner to promote the persistence of dicalcium phosphate in the soil.

It was concluded that, in well-limed soils, calcium fluorphosphate, or "precipitated apatite," is probably the ultimate end product of incorporations of superphosphate. In such soils the incorporated superphosphate seeks a return to the form of its occurrence in rock phosphate.

Development of Processes for the Production of Metaphosphates

Raymond L. Copson, Gordon R. Pole and William H. Baskervill, Tennessee Valley Authority, Wilson Dam, Alabama

Since the experimental production of calcium metaphosphate fertilizer by the TVA was first described in 1937, a considerable tonnage of this material has been produced, and it has been supplied for test and demonstration purposes in every section of the United States.

One method of production has been described previously, consisting of burning phosphorus with air and bringing the hot products

of combustion into contact with lump rock phosphate packed in a vertical shaft. A second method is being developed to utilize phosphate sands, which are blown into the chamber in which the phosphorus is burned. In both cases most of the fluorine of the rock phosphate is volatilized, and fluorine compounds may be recovered as by-products.

Similar methods also are being developed for the production of metaphosphates of the alkali metals from their chlorides.

In small pilot plants in which phosphorus was burned with moist air, three different methods of introducing the chloride were tried: (1) as a solid agglomerate packed in a vertical shaft; (2) as the fused salt flowing over a refractory packing material in the shaft; and (3) as a powdered solid blown into the phosphorus combustion chamber. By the third method, more than 40 tons of fused potassium metaphosphate fertilizer were produced in a continuous run of the pilot plant. Products containing metaphosphates of both potassium and calcium, and of variable composition, also were produced from mixtures of phosphate sands and potassium chloride.

Defluorination of Fused Rock Phosphate

Kelly L. Elmore, Ernest O. Huffman and William W. Wolf, Tennessee Valley Authority, Wilson Dam, Alabama

The defluorination of fused rock phosphate was studied at temperatures varying from 1,450° to 1,600° C. The effects of the composition and depth of charges, concentration of water vapor, and velocity of the furnace atmosphere upon the rate of defluorination were investigated.

The mechanism of the defluorination was found to be controlled by (1) diffusion through the gas film for charges up to 0.5 cm. deep at 1,500° C. and slightly greater than 1 cm. deep at 1,600° C. and (2) diffusion in the melt for deeper charges at the respective temperatures. When diffusion through the gas film was the controlling mechanism, the rate of defluorination was found to vary as the 0.3 power of the velocity of the furnace atmosphere and the 0.45 power of the water vapor concentration. When diffusion in the melt was the controlling mechanism, the rate of defluorination increased when the temperature was increased, or when silica, or silica and iron oxide, were added to the rock phosphate before fusion.

Well-formed crystals of alpha-tricalcium phosphate were observed in the completely defluorinated products.

Some Recent Developments in the Phosphate Field

Henry W. Easterwood, Patent Department, Victor Chemical Works

A brief review of some of the developments relating to the manufacture and uses of the newer phosphates and phosphorus-containing compounds is given, together with numerous literature and patent citations.

Defluorinated phosphate rock is briefly discussed from the point of view of its research development. The use of tricalcium phosphate for the removal of fluorine from drinking water is briefly reviewed. The development of the alkali metal meta- and poly-phosphates is briefly reviewed, including a fairly extensive patent bibliography.

Tetrasodium pyrophosphate is reviewed with respect to its detergent use in connection with soap compositions. The development of special anhydrous monocalcium phosphate baking acid is discussed.

Organic phosphorus-containing compounds are discussed very generally, including the aryl and alkyl phosphates and phosphites. The phosphites and other trivalent phosphorus organic compounds are mentioned in connection with their use in lubricating oils. A classified list of about 40 patents on the latter subject is included.

A number of miscellaneous developments are briefly mentioned, including phosphorated oils, fodder preservatives, flotation promoters, etc. The literature and patent citations under each subject are not complete but will enable the reader to obtain quickly a more detailed knowledge of the subject.

Food and Industrial Phosphates

A. E. Marshall, Rumford Chemical Works

Interest in the chemistry of phosphorus and its compounds, as indicated in the early records of chemical research, may be attributed to its wide occurrence in nature, its unusual properties which led to the name "phosphorous mirabilis," and to the importance of its compounds as food material for plants an animals.

In classifying compounds, the phosphates are by for the most important and most widely used. The necessity of providing a source of phosphate in the human diet was recognized and led to extensive systematic studies by numerous investigators. The effect of phosphate has been investigated both with regard to its own importance as a nutrient and because of its influence on the availability of other elements necessary to ensure normal de-

(Continued on page 26)

A Critique of Field Experiments with Plant Nutrients

By DR. O. W. WILLCOX
Technical and Agricultural Editor of "Sugar," New York

(Continued from the August 30, 1941, issue)

THE above considerations flow naturally and surely from the first two of the three major principles of quantitative plant biology. These principles are the absolute reproducibility of plant growth in a fixed (closed) environment, and the absolute differentiation of plant varieties by their quantities of life. According to these principles every definite environment suitable for plant growth will then and there produce a definite crop yield, and this definite yield is exactly repeated when the same conditions are duplicated. With this fundamental truth in mind, we may go back again to the Hamakua experiment with potash on sugar cane (Table I).

Consider plot No. 55 of the G series which produced at the rate of 53.1 tons to the acre. Note that this yield is not 46 tons nor 60 tons and does not duplicate any other yields found in this series. The yield of plot No. 55 is 53.1 tons because that figure is the exact measure of the mass-action equilibrium between the reaction-strength of the soil member and the reaction-strength of the plant member of the closed system then and there existing on that plot. And from the major principles of quantitative plant biology previously referred to, we know that this yield of 53.1 tons from plot No. 55 will be exactly reproduced in any environment that exactly duplicates the system then and there existing. That is to say, the agrobiologic system which the experimenter has found on plot No. 55 has the ability to turn out a certain constant yield if the same conditions are maintained. The weigh-scales have certified that the constant yield producible on such a plot as No. 55 is 53.1 tons per acre, no more and no less.

Consider also the next G plot, No. 74, which produced at the rate of 57.2 tons. Why did not plot No. 74 yield 53.1 tons like its companion no-potash plot No. 55? The occurrence of such variations between individuals of the same sample infuses the statistician with a suspicion that chance has been at play. But no competent experimenter could make anything like an error of 4.1 tons in ascertaining the yields of these two plots. The yield of plot No. 55 is 53.1 tons and of plot No. 74 it is 57.2 tons because these two figures are the respective measures of the two agrobiologic equilibria then and there existing on these two plots, and these equilibria are not vagrant variables but reproducible constants. In the same sense all other G yields are constants, the sum of these yields is a constant, and the average of these yields is also a constant. The upshot is that the average yield of the G series is not 47.2 ± 2.21 tons but 47.2 ± 0 tons, or, at any rate, 47.2 tons plus or minus an infinitesimal which is of no practical importance.

Also in the same agrobiologic sense the yield of the H series is 50.5 ± 0 tons and of the I series it is 52.3 ± 0 tons. The difference be-

Table I.
Hamakua Experiment 41 AK, 1938 Crop

G series, 0 lb. K_2O per acre: Plot No.	Yield, tons	H series, 175 lb. K_2O per acre: Plot No.	Yield, tons	I series, 350 lb. K_2O per acre: Plot No.	Yield, tons
55	53.1	64	65.3	73	56.6
74	57.2	56	62.6	65	63.1
56	53.9	75	50.1	57	51.0
58	43.3	67	36.3	76	48.9
77	42.8	59	44.0	68	45.5
69	48.5	78	43.1	60	56.7
61	38.3	70	48.5	79	46.9
80	44.9	62	56.8	71	49.5
78	42.9	81	47.9	63	43.5
Average yields:	47.2 ± 2.21		50.5 ± 2.75		52.3 ± 1.85

tween G and H, 3.3 tons, is an agrobiologic constant; the difference between H and I, 1.8 tons, is an agrobiologic constant, and the spread of yield between G and I, 5.1 tons, is an agrobiologic constant. Before the experiment all these magnitudes were unknown; at the close of the experiment the weigh-scales had only to identify them and proclaim their numerical values, and from the decision of the weigh-scales there can be no valid appeal. There being only infinitesimal errors due to operative lapses or to biological variation, and variations in plot yields not being the product of chance or tainted with anything that can be legitimately called error, there is nothing on which a statistician may usefully lay his hands. The operator may accept the demonstrated increase at its face value and make his agronomic dispositions accordingly, untroubled by misgivings which the statisticians unwarrantably raise.

Difference between Fertilizer Tests and Other Experiments

At this point, reference may again be made to the distinction which the writer has drawn between field experiments with plant nutrients and field experiments on other agronomic objects. Application of analysis of variance to the former is discounted as not merely useless but on occasion positively misleading (see further on). On the other hand, in variety tests, spacing tests, etc., where specific properties of plants themselves are in question, use of the same statistical procedure can hardly be avoided. Why make fish of the one case and fowl of the other?

This discrimination is based on a distinction between pertinent and impertinent variants. In a variety test, for instance, besides the negligible operative errors and the equally negligible biological variations (competent work presupposed), there are simultaneously present two major sources of variation. On the one hand are variations due to differences in quantity of life possessed by the agrotypes; these are the pertinent variations which the experiment is designed to evaluate. On the other hand are variations in yield due to soil variability which are impertinent or irrelevant to the inquiry in hand. It is a case where pertinence is contaminated by a non-negligible amount of impertinence, and the impertinence must be cast out in order to get at the pertinent values. It is here that analysis of variance may render a useful but not the best imaginable service. The ideal way to make a variety test would be to lay it down on an absolutely uniform soil (if such could be found); the impertinent variable would thus be entirely excluded. The next best thing would be to predetermine the variability of the soil by a well controlled uniformity test and introduce corrective coefficients thus found into the subsequent variety test on the same area, but this also has its drawbacks.

The necessity of resorting to statistical methods for separating pertinence from impertinence is to be regarded as a misfortune; the separation is never complete; a larger or smaller trace of impertinence always remains to be expressed as the standard error. The most that can be hoped for is that differences in treatment yields will be statistically "significant" and not likely to involve "odds" greater than 1:19, or 1:99.

On the other hand, in a well conducted field test with a plant nutrient no impertinent variable is present. Just as the impertinent variable in a variety test (soil variability) could be made to disappear entirely by laying down the experiment on a uniform soil (which is impracticable), so in a plant nutrient test the opposite impertinent variable (biological variation) can be excluded by using a single homozygous genotype or stabilized agrotype as the test plant, and this is entirely practicable. Thus in a well conducted field test with a plant nutrient, operative error and biological variation are negligible, only the pertinent variable comes up for measurement.

No Room for Chance

It is here that the devisers and users of statistical methods for evaluating field experiments with plant nutrients make their great mistake. They regard as chance that which is not the product of chance nor tainted by chance in any appreciable degree. The only imaginable source of impertinence that can be present in a well conducted experiment of this kind are operative errors, which in sum amount only to an infinitesimal, and are certainly vastly smaller than variations in plot yields such as are seen in the Hamakua experiment. If the small operative errors could be separated from the varying but agrobiologically definite yields, their small significance might be defined by a statistical analysis, but so far as I know the statisticians have not proposed a method for making the separation which agrobiologists can regard as acceptable. As it is, the small needle of impertinence is lost in the great haystack of pertinence and it will not be worth while to look for it, certainly not by methods which unwarrantably substitute large doubts for what is practical certainty. On these grounds, application of current statistical methods for evalu-

ating field experiments with plant nutrients is discounted as not merely useless but on occasion positively misleading.

Thus, on *a priori* grounds the agrobiologically informed field experimenter who knows that he can trust his own work is disposed to accept the result of his experiment at its face value. If he finds that an application of 175 pounds of potash has produced a yield increase of 3.3 tons to the acre, and that an additional 175 pounds has produced a further increase of 1.8 tons, he has data, the reliability of which is guaranteed by the first two major principles of quantitative plant biology. He may then proceed to a further evaluation of this data in the light of the third major principle of quantitative plant biology, which is that when applications of a plant nutrient are increased by equal increments, the yields of plants increase by diminishing increments. This principle is called the law of diminishing increments of yield, which was first given that name by the late W. J. Spillman.[3] All agronomists are aware that when the mass or intensity of a factor of plant growth is increased, the resulting yield curve asymptotically approaches a limit.

The characteristics of the *normal* yield curve of plants have been known for three decades, beginning with the pioneer work of Mitscherlich. The characteristics of this curve are *normally* the same, regardless of the kind of plant or of the factor of plant growth. This *normal* yield curves furnishes a means for the further evaluation of a field test with a plant nutrient. This phase of the evaluation of the experiment takes the form of a process for determining the positions of the average yield figures relative to the *normal* yield curve. (Note that we are persistently italicizing the world *normal*, for reasons which appear below.) The *normal* yield curves is defined by the Mitscherlich-Baule yield equation:

$$\log (A - y) = \log A - 0.301x.$$

The derivation of this equation and the meaning of its symbols are familiar to many agronomists and may be readily learned from the literature.[4] The writer has lately devised a diagram[5] by which the data of a field experiment may be fitted on a Mitscherlisch-Baule yield curve in a pair of minutes, without any mathematical calculations. Thus, when this diagram is applied to the data of the Hamakua experiment with potash, we obtain the picture presented by Fig. 1.

The construction and use of this diagram are explained in the publication referred to.[5] In brief it consists of a number of Mitscherlich-Baule curves, each calculated on the basis of a certain value of *A*, as 10, 10.5, 11, 11.5, etc., up to 25; portions of the normal yield curves 15 to 21 (heavy lines) are shown in the draw-

[3] Spillman, W. J. *The law of diminishing returns.* (World Publishing Co., Yonkers, N. Y., 1924).

[4] Mitscherlich, E. A. *Die Bestimmung der Nährungsbedurfnisses des Bodens* (Paul Parey, Berlin, 1924); Willcox, O. W. *A B C of Agrobiology* (Norton, New York, 1937).

[5] Willcox, O. W. The fertilization of sugar cane. I. A simple graphical method of evaluating tests with fertilizers. *Facts About Sugar*, vol. 35, No. 12, 33-37 (1940). II. The agrobiologic evaluation of some potash tests. *Ibid.*, vol. 36, No. 6 (1941).

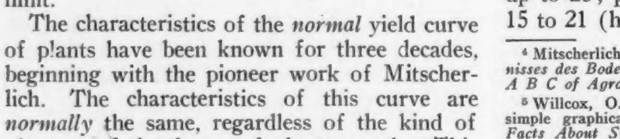

FIG. 1. Yield diagram of Hamakua potash test in Hawaii. Reducing divisor 3.

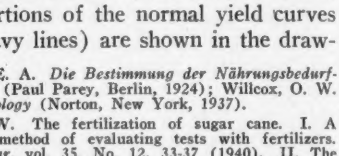

FIG. 2. Yield diagrams of three potash tests on sugar cane in Mauritius. Reducing divisor 2.

ing. The axis of ordinates is divided to show units of yield from 0 to 20. Since it would be inconvenient to handle a diagram showing a large range of yield numbers (up to 200, for instance), where the figures range higher than 20 they are divided by a factor that will reduce the range below 20. This being understood, the Hamakua data are prepared for diagramming as in Table II.

Table II

Rearranged Data of the Hamakua Experiment

Series	Potash Applied lb./acre	Baule Units	Average Yields Observed	Divided by 3
G	0	0	47.2	15.73
H	175	2.134	50.5	16.83
I	350	4.268	52.3	17.43

To bring the yield figures within the diagram, they are divided by 3. On a sheet of transparent paper a line is drawn to represent the base of the diagram. Above this line, pencil dots representing the reduced yields are spaced according to their numerical values as ordinates and horizontally according to the Baule units used in the treatments (a Baule unit of potash is 82 lb., acre basis). The line on the transparent paper is placed on the base of the diagram and the paper is slid back and forth until a position is found such that lines joining the three yield points transect the fewest curves. In this case the points group themselves on or near curve 17.5. G is visually estimated to lie on curve 17.77, H on curve 17.30 and I on curve 17.55. Table III may then be made up.

Table III

Results of Diagramming the Hamakua Experiment

Series	Curve Position of Yield	Curve Position x 3	Deviation from the Average
G	17.77	53.31	0.69
H	17.30	51.90	0.72
I	17.55	52.65	0.03
Averages:	17.54	52.62	0.48

Multiplication by 3 after division by 3 restores the original relations. The small deviations from the average indicates that this field, although its various parts show wide differences in crop-producing ability, behaves *on the whole* as though the original fertilities of the H and I series were very nearly the same as that of the G series.

The diagram indicates curve $A = 17.5 \times 3 = 52.62$ as the limit response to potash on this field. The I yield lies at 52.3, which is so close to the limit as to indicate that more than 350 pounds of potash would produce no appreciable increase. From the position of the G point along the abscissae, 3.3 units from the origin, it is deduced that the untreated field as represented by the G series had an original potash content of 3.3 Baule units.* Both these conclusions represent valuable information not obtainable by statistical analysis.

A Mauritius Field Test

A further instance of the application of the yield diagram to field experiments with a plant nutrient will be found in a group of potash tests on sugar cane at three sugar estates in Mauritius.[6] The data are shown in Table IV.

Table IV

Data of Three Potash Tests in Mauritius

K_2O, lb./acre	Yields, tons/acre B	RB	RF
0	18.6	19.9	28.8
20	19.2	22.2	33.2
40	19.2	22.9	29.3
60	20.5	23.6	32.0
Significant dif.	2.2	2.9	5.9

The letters B, RB and RF designate the three estates. The reducing divisor for diagramming is 2. When the data are diagrammed, we get the picture presented by Fig. 2.

When these data are analyzed statistically, it is seen that the experiments B and RF have failed to reach significance, although it is plainly to be seen that some increase in yield has occurred. In the RB experiment, only the two largest applications gave increases large enough to be considered significant. The yield diagram shows that in the B experiment the results conform closely to curve $A = 11.41 \times 2 = 22.82$; the average deviation from this curve is 0.52, or about 2 per cent. The field has an original potash content of 2.37 Baule units; the yield from the largest application is still 2.3 tons below the indicated limit.

At RB the indicated normal yield curve for the experimental field is $A = 14.63 \times 2 = 29.26$. Deviations from this normal yield curve lie between 0.07 and 0.37 ton, average 0.19 ton, or somewhat less than 1 per cent. The original potash content of the soil was 1.7 Baule units; the yield curve is still steeply rising, and the increases obtainable from potash have still 5.66 tons to go before reaching the limit.

Such experiments as the one at RF are the despair of agrobiologically uninformed users of statistical methods for evaluating this kind of test. The four yield points show a very marked irregularity. A practiced statistician would hardly bother to make an analysis of variance

* This figure 3.3 is the "b" in the Mitscherlich yield equation: $\log (A - y) = \log A - c (x - b)$.

[6] Craig, N. Manurial experiments. *Tenth Annual Report of the Sugarcane Research Station* (Mauritius, 1939), p. 21.

(Continued on page 24)

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Principal Articles in This Issue

September Cotton Report

A United States cotton crop of 10,710,000 bales is forecast by the Crop Reporting Board of the United States Department of Agriculture, based on conditions as of September 1, 1941. This is a decrease of 107,000 bales from the forecast as of August 1st, and compares with 12,566,000 bales in 1940, 11,817,000 bales in 1939, and 13,246,000 bales, the 10-year (1930-39) average. The indicated yield per acre for the United States of 226.8 pounds compares with 252.5 pounds in 1939, and 205.4 pounds, the 10-year average. It is estimated that 3.8 per cent of the acreage in cotton on July 1st has been, or will be, abandoned, leaving 22,633,000 acres remaining for harvest. In 1940 the abandonment was 4.1 per cent. In computing abandonment, consideration was given to the acreage removed in order to comply with AAA allotments.

The Census report shows 504,125 running bales (counting round as half bales) ginned from the crop of 1941 prior to September 1st, compared with 605,764 for 1940 and 1,401,691 for 1939.

	Production (Ginnings)[1] 500 lb. gross wt. bales		
State	Average, 1930-39 1,000 bales	1940 Crop 1,000 bales	1941 Crop Indicated Sept. 1 1,000 bales
Missouri	292	388	378
Virginia	33	25	22
N. Carolina	629	739	516
S. Carolina	824	966	411
Georgia	1,132	1,010	628
Florida	32	21	14
Tennessee	465	509	511
Alabama	1,145	779	768
Mississippi	1,585	1,250	1,366
Arkansas	1,281	1,501	1,361
Louisiana	703	456	384
Oklahoma	750	802	627
Texas	3,766	3,234	2,888
New Mexico	100	128	122
Arizona	159	195	226
California	333	545	470
All other	16	18	18
UNITED STATES	13,246	12,566	10,710
Sea Island[2]	...	4.0	3.3
Amer. Egyptian[2]	17	33	78
Lower Calif. (Old Mexico)[3]	38	60	90

[1] Allowances made for interstate movement of seed cotton for ginning.

[2] Included in State and United States totals. Sea Island grown principally in Georgia and Florida. American Egyptian grown principally in Arizona.

[3] Not included in California figures, nor in United States total.

Since August 1st prospective cotton production has been reduced in the central part of the Cotton Belt, but this decline is nearly offset by increases in Oklahoma, Texas, New Mexico, Virginia, and North Carolina. These changes are largely due to weather conditions during August. Weather was less favorable than average in the States from Georgia to Arkansas and Louisiana, and boll weevils have caused serious injury to the crop throughout this area. In Oklahoma and Texas favorable moisture conditions have stimulated plant growth and weevil damage is not generally serious this season. In these two States, however, the crop is still about two weeks later than usual. In Virginia and North Carolina hot weather held weevils in check and permitted the plants to set more bolls than were expected a month ago. In California the crop is later than usual and has been retarded to some extent by relatively cooler weather than usual. In Missouri the extremely high yields in prospect a month ago were reduced to some extent by unusually hot, dry weather during early August.

ALMOST ALL FERTILIZERS UNDER EXPORT LICENSE

Export control schedule No. 17, which became effective on August 29th, includes additional fertilizers and fertilizer materials so that all fertilizers and fertilizer materials except low-analysis potash salts are now under export control. This means that an export license is necessary in order to ship any such materials out of the country. However, blanket licenses have been issued which permit the shipment of practically all fertilizers and fertilizer materials to Canada, Great Britain, and the Phillippines without individual licenses. Certain fertilizers and fertilizer materials are permitted to be shipped to South America and Central American countries, and a number of other countries specifically listed under the blanket license. Export to the Axis powers or to countries controlled by them is not permitted under present orders.

PRIORITIES OPEN SIXTEEN FIELD OFFICES

The Priorities Division of OPM has opened 16 field or district offices in order to assist manufacturers and other business men who need information or advice in connection with the operation of the priorities system. The district offices are located in the following cities: Atlanta, Ga.; Boston, Mass.; Chicago, Ill.; Cincinnati, Ohio; Cleveland, Ohio; Dallas, Tex.; Denver, Colo.; Detroit, Mich.; Kansas City, Mo.; Los Angeles, Cal.; New York, N. Y.; Philadelphia, Pa.; Pittsburgh, Pa.; St. Louis, Mo.; San Francisco, Cal.; Seattle, Wash.

The National Fertilizer Association is continuing its efforts to have the fertilizer industry covered in some manner in a blanket license so that at least material and repair parts can be obtained for factory maintenance.

UNION POTASH MOVES SOUTHERN SALES OFFICE

J. W. Rutland, Southern Sales Manager of the Union Potash & Chemical Co., has announced the removal of their southern sales office in Atlanta to new quarters in the Volunteer Building. All business in the southern territory will be handled from this office, and members of the industry are invited to make use of the new accommodations when in Atlanta.

SOUTH CAROLINA FERTILIZER SALES

The Fertilizer Department of the Clemson Agricultural College report sales, for the year ending June 30, 1941, of 668,016 tons of fertilizers. Of this total, 404,751 tons were of registered mixed goods, 242,554 tons were of individual materials, and 20,711 tons were goods manufactured to customers' specification. There were 100 grades of mixed goods sold, of which 7 accounted for 70 per cent of the mixed goods total. These seven grades were: 3-8-5, 90,562 tons; 4-8-4, 57,640 tons; 5-7-5, 43,751 tons; 4-8-6, 32,350 tons; 4-7-5, 21,156 tons; 3-10-3, 20,092 tons; 2-10-4, 19,035 tons.

DAVISON SHOWS PROFITS INCREASE

The annual report of the Davison Chemical Corporation for the year ended June 30, 1941, shows net income of $652,311, equivalent of $1.26 per share of stock outstanding on that date. Total sales for the year showed a decrease of about 5 per cent, due to the elimination of some divisions of the company in June, 1940. The increase in sales of the remaining divisions accounted for the increase in net profits. A dividend of 60 cents per share was paid in June, 1941.

Tobacco Fertilizer Recommendations for South Atlantic States

RECOMMENDATIONS for fertilizer to be used on average soils during 1942 in growing flue-cured tobacco in Virginia, North Carolina, South Carolina, Georgia and Florida have been issued by the Agronomy Tobacco Work Conference, following a meeting held at Oxford, N. C. The conference is composed of state and federal agricultural officials as follows: C. B. Williams, *North Carolina*, chairman; T. B. Hutcheson, *Virginia*, secretary; W. W. Garner and J. E. McMurtrey, *U. S. Department of Agriculture;* W. E. Stokes, *Florida;* E. C. Westbrook, *Georgia;* E. G. Moss, L. T. Weeks and E. Y. Floyd, *North Carolina;* H. P. Cooper, H. A. McGhee and J. F. Bullock, *South Carolina;* E. M. Mathews, *Virginia.*

Fertilizers for Flue-Cured Tobacco

A. Analyses of Mixtures and Rates of Application

(1) *For Heavy or More Productive Soils*—Three per cent total nitrogen, ten per cent available phosphoric acid, and six to twelve per cent potash. To be applied at rates of 800 to 1,000 pounds per acre.

(2) *For Light or Less Productive Soils*—Three per cent total nitrogen, eight to ten per cent available phosphoric acid, and six to twelve per cent potash. To be applied at the rates of 800 to 1,200 pounds per acre.

(3) *Reduction in Nitrogen*—Where tobacco has a tendency to be rough and of poor quality, the nitrogen may be reduced to 2 per cent. For such conditions, two per cent total nitrogen, ten to twelve per cent available phosphoric acid, and six to twelve per cent potash is suggested. To be applied at rates of 800 to 1,000 pounds to the acre.

(4) *Additional Potash*—Experiments indicate that potash has an important influence on yield and quality in flue-cured tobacco. It is, therefore, suggested that when less than 50 pounds of K_2O (6 per cent potash in an 800 pounds to the acre application) is applied at planting time, or where potash deficiency is indicated, that potash to the extent of 50 to 120 pounds of K_2O (100 to 250 pounds of sulphate of potash equivalent) to the acre be applied as additional side-dressings within 20 days after transplanting. High chlorine salts should not be used as top dressers.

(5) *Method of Application*—Experiments indicate that fertilizers applied so as to come in direct contact with the plant roots cause loss of plants and retard early growth. It is, therefore, suggested that fertilizers be placed in bands 3 to 4 inches to the sides of the row at the approximate level or slightly below the root crowns and the plants be set between these bands, or that the fertilizer be *thoroughly* mixed with the soil in the furrow before bedding. Where proper machinery is not available for side applications, it is suggested that 60 per cent of the fertilizer be applied at planting and the remainder as a side-dressing approximately 20 days after setting.

Note 1—The above analyses may be modified, provided the given ratios are maintained and the recommended sources of plant food are used.

Note 2—Where more than 6 per cent potash is used, farmers are cautioned to apply fertilizer in bands or mix thoroughly with soil to prevent plant injury.

(Continued on page 22)

FERTILIZER MATERIALS MARKET

NEW YORK

Little Buying of Fertilizer Organics with Greater Activity in Feed Materials Market. Sulphate of Ammonia, Phosphates and Potash Salts Continue Scarce.

Exclusive Correspondence to "The American Fertilizer."

NEW YORK, September 9, 1941.

There has been no increase in the buying of organic materials by fertilizer manufacturers although the organic market has been quite active, due to increased buying of feeding materials.

Sulphate of Ammonia

This material continues scarce and it appears that the British Purchasing Commission have not as yet been able to fully book the 10,000 tons for which they are in the market.

One of the large sellers of ammonia liquors has advised the trade of the probability that contracts for various liquors will not be completely fulfilled and this situation will probably aggravate the sulphate of ammonia situation.

Superphosphate

Due to the general scarcity of sulphuric acid, this material is scarce.

Triple Superphosphate

This is practically unobtainable; all manufacturers are evidently fully sold up with prospects of production not being up to anticipation. Here again this is due to scarcity of sulphuric acid.

Potash

There is no change in the situation regarding this commodity, the production being contracted for. The prospects are that there will be no easing of this situation during the entire season.

Fish Scrap

Fishing continues to be favorable. Following a little business at $4.35 ($5.29 per unit N) and 10 cents, supplies are now being held at $4.50 ($5.47 per unit N) and 10 cents, f.o.b. fish factories.

Tankage

No offerings of South American tankage because it is impossible to get freight space.

Dried Blood

This market is very strong, South American material being quoted at $3.75 ($4.56 per unit N).

BALTIMORE

Slow Start of Fall Season May Affect Tonnage. Stocks of Nitrate of Soda Low. Fish Scrap Production at High Level.

Exclusive Correspondence to "The American Fertilizer."

BALTIMORE, September 9, 1941.

The fall season is getting away to a slow start, due to continued dry and warm weather, and this condition, with crop restrictions, would make it appear that the tonnage this fall will be somewhat less than last fall.

Ammoniates.—The market on ground animal tankage continues high, due to the demand for feeding purposes, being in the neighborhood of $5.25 per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. Baltimore. Ground dried blood has also moved up somewhat during the past two weeks, and is selling at about $4.20 per unit of nitrogen, c.a.f. Baltimore.

Nitrogenous Material.—With curtailment in domestic production, there is none offering at present, and the market is nominally quoted at $3.75 per unit of nitrogen, f.o.b. Baltimore.

Sulphate of Ammonia.—There is no change in the situation and the nominal market continues at $29.00 per ton, in bulk at ports, but there is no more obtainable at this figure. Buyers are taking deliveries as fast as they can get them, storing up any surplus not needed this fall against their spring requirements.

Nitrate of Soda.—Stocks of both domestic and imported nitrate are at the lowest ebb they have been for many years, although it is expected that there will be replenishment of the Chilean product toward the end of next month. The price for September and October delivery

of the imported material is unchanged at $33.00 in 100-lb. bags; $32.40 in 200-lb. bags; and $30.00 per ton in bulk, f.o.b. port warehouse. Domestic nitrate is priced at $29.40 in 100-lb. bags; $28.70 in 200-lb. bags; and $27.00 in bulk, f.o.b. ports or producing points.

Fish Scrap.—The catch on the Chesapeake Bay continues good, with every indication that it will be larger this year than for sometime past. The market continues unchanged at about $5.40 per unit of nitrogen and 10 cents per unit of B.P.L., f.o.b. fish factory, in bulk, for shipment "if and when made." Most of the buyers have now covered for their approximate requirements for the coming season and not much change is anticipated in the market.

Superphosphate.—There are no large stocks accumulating, and producers continue to quote $9.50 per ton of 2,000 lb., basis 16 per cent for run-of-pile, and $10.00 for flat 16 per cent grade, both in bulk, f.o.b. Baltimore. There is great danger of further allocation of rock vessels to other lines, which would result in a very critical situation, as it is doubtful whether the railroads would be able to deliver sufficient tonnage by cars even if manufacturers were equipped to handle carload shipments.

Bone Meal.—The market on both raw and steamed bone is inactive, and the market is nominally $37.50 for 3 and 50 per cent steamed bone meal, and $37.00 to $38.00 for 4½ and 47 per cent raw bone meal, f.o.b. Baltimore.

Potash.—There is no change in conditions and it is now anticipated that American producers will be able to supply the domestic demands. Practically all producers are sold up and contract deliveries are now being made.

Bags.—The market on burlap has eased off, and figures about $190.00 per thousand for plain, new, 10-oz. bags, basis 40 cut 54 in., delivered Baltimore, which represents a material reduction from prices prevailing a month ago.

ATLANTA

Improvement in South American Shipping Service Expected. Increase in Cottonseed Prices Indicated by Short Crop.

Exclusive Correspondence to "The American Fertilizer."

ATLANTA, September 9, 1941.

With the taking over, by South American governments, of some hundred Axis' ships in these various countries, it is to be hoped that the freight situation with reference to shipments from South America to the United States will be ameliorated to some extent. Whether these ships will be immediately available or whether they have been subject to sabotage and will have to be repaired, remains to be seen. At any rate, with most of the rest of the world cut off, our trade with our neighbors to the South should be helped by this development and it should enable us to receive larger quantities of fertilizer materials such as are produced in South America.

The Government estimate on the cotton crop, as issued yesterday, indicates a crop of 10,710,000 bales which is a slight reduction from the previous estimate. It is now becoming apparent that cottonseed may go to $60.00 per ton here in the South, in which event 15 cent oil and $50.00 cottonseed meal will not be out of reason. Heavy buying of all proteins has been in progress for some time past and apparently the end is not yet in sight.

Processed tankage is still in demand and at current levels is apparently attractive, based on consumer buying.

The markets generally are as follows:

Imported Tankage.—$4.50 ($5.47 per unit N) and 10 cents, c.i.f.

South American Blood.—$3.60 ($4.37½ per unit N), c.i.f.

Domestic Nitrogenous Tankage. — $2.50 ($3.04 per unit N), western producing points.

Menhaden Machine Dried Scrap.—$4.35 ($5.29 per unit N) and 10 cents, buyers bags, f.o.b. Chesapeake Bay producing points

Acidulated Fish.—Supply well absorbed.

Sulphate of Ammonia.—Good demand but offerings limited.

Nitrate of Soda.—No change.

Cottonseed Meal.—Prime 8 per cent, $43.00, Memphis; Southeastern mills, $42.00 to $44.00.

TENNESSEE PHOSPHATE

Rock Production Should Pass Million Ton Mark in 1941. Calcium Silicate Slag in AAA Program.

Exclusive Correspondence tc "The American Fertilizer."

COLUMBIA, TENN., September 8, 1941.

If the remainder of 1941 shows the same margin of increase over 1940 that is in evidence from shipments up to date, the production of the Tennessee phosphate field will run well over the million ton mark whch it has so closely approximated for 1939 and 1940. Although at least a fourth of this tonnage is now grade material (50 to 55 per cent B.P.L.), which could not be shipped several years ago, but now enters largely into furnace production of elementary phosphorus at Monsanto, Mt. Pleasant, and Muscle Shoals, reduction of the total to 70 per cent basis would leave around one million tons compared with the old time high of 700,000 tons in 1930.

Farmers are actively preparing for the AAA program of spreading limestone and calcium silicate slag, as they get benefit payment of $1.50 per ton and can buy it spread on their fields for $1.35. New York refuses to accept this silicate slag as a liming material, but experiments of the University of Tennessee accord it even better results than ordinary calcium limestone, not quite so good as dolomite. Some of the value of this silicate slag is attributed to its content of phosphorus but no such value is attributed to the low grade muck phosphate which farmers could buy for $3.00 per ton applied to their land and get $6.00 per ton in benefit payments, making a profit of $3.00 instead of 15 cents per ton.

The extensive changes which Hoover & Mason Phosphate Co. have been preparing for during most of this year, have reached a stage where it will be necessary to shut down the washer plant entirely on September 15th for several weeks but this will not affect drying and grinding operations from the large storage effected during the past few months.

Shipments of ground rock to farmers for direct application during August, 1941, exceeded August, 1940, by over 50 per cent and September bids fair to go even higher, indicating that the AAA activities have had somewhat the same effect on the business of private concerns as in superphosphate sales.

CHICAGO

Fertilizer Manufacturers Waiting Developments in Organics Market before Buying Further. Feed Market Firm.

Exclusive Correspondence to "The American Fertilizer."

CHICAGO, September 8, 1941.

The tone of the western ammoniate market continues strong although trading is not overly brisk. Many fertilizer manufacturers report that their anticipated early requirements are covered, and therefore prefer awaiting developments before making new commitments.

The feed market has turned exceedingly firm; list prices of digester tankage and meat scraps were raised $2.50 per ton.

Nominal prices are as follows: High grade ground fertilizer tankage, $3.50 to $3.75 ($4.25½ to $4.56 per unit N) and 10 cents; standard grades crushed feeding tankage, $4.85 to $5.00 ($5.89½ to $6.08 per unit N) and

10 cents; blood, \$3.75 to \$3.90 (\$4.56 to \$4.74 per unit N); dry rendered tankage, \$1.00 to \$1.05 per unit of protein, Chicago basis.

WILMINGTON

Organics Prices Advance with Little Buying Interest. Fishing Season Disappointing. Cottonseed Meal Higher.

Exclusive Correspondence to "The American Fertilizer."

WILMINGTON, September 8, 1941.

There is very little buying interest at the present time. In spite of this, organics are advancing to higher levels and there is very little tonnage of any sort being offered. The knowledge that there will be a definite shortage of water-soluble ammoniates is no doubt responsible for the firmness of the market.

The catch of menhaden fish continues to be very disappointing and, in Carolina waters at least, this has been the poorest year in sometime. All of the producers have unfilled contracts and very little tonnage can be bought at this time.

Cottonseed meal has advanced sharply and the mills are reluctant to quote any price at the present time.

PHILADELPHIA

Little Present Buying but Improvement Expected. Shortage in Some Items Expected.

Exclusive Correspondence to "The American Fertilizer."

PHILADELPHIA, September 10, 1941.

Trading in general has been very dull during the past interval, but indications point to a revival of buying. There is considerable inquiry for various materials, and shortages in some items are evident for the near future.

Sulphate of Ammonia.—New contracts practically impossible.

Nitrate of Soda.—Supplies on hand limited.

Blood.—There has been some buying and sellers are now holding at from \$3.55 to \$3.70 (\$4.31½ to \$4.49½ per unit N), f.o.b. shipping points.

Tankage.—Feeding interests have markets well cleaned up. The few offerings that do appear are held at around \$4.75 (\$5.77½ per unit N) and 10 cents.

Bone Meals.—Feeding grades of quality practically unobtainable. A few small lots of fertilizer grade appear at high figures.

Superphosphate.—Market unchanged, with no inquiry.

Potash Salts.—Not plentiful.

CHARLESTON

Some Buyers Worried About Shortage of Materials. Organics Scarce with Some Price Increases.

Exclusive Correspondence to "The American Fertilizer."

CHARLESTON, September 10, 1941.

The scarcity of mineral fertilizer materials continues, with some buyers seriously disturbed by their inability to obtain sufficient supplies.

Nitrogenous.—This continues scarce, with quotations harder to obtain. Quoted around \$2.90 (\$3.52½ per unit N), delivered southeastern ports.

Blood.—Around \$3.50 (\$4.25½ per unit N), bagged, c.i.f., where freight can be obtained. Bulk at \$3.60 (\$4.37½ per unit N), f.o.b. Chicago.

Fish Meal.—This is also fairly scarce with quotations at \$65.00 per ton f.o.b. Baltimore.

Cottonseed Meal.—\$40.00 per ton for 7 per cent grade at Augusta; \$42.00 for 8 per cent grade at Memphis.

Superphosphate.—The market on this has advanced and sellers are not pushing sales.

AGRICULTURAL PRODUCTION CAMPAIGN

On September 8th, Secretary of Agriculture Wickard announced plans for a 1942 farm production campaign to provide for complete mobilization of American agriculture, to meet domestic needs for defense as well as the needs of nations resisting aggression. The campaign will be under supervision of State and county defense boards, made up of representatives of all agriculture department agencies in the field. Regional meetings to discuss the part that agriculture will be called on to play next year will be held at Salt Lake City, Sept. 15th-16th; Chicago, Sept. 18th-19th; New York, Sept. 24th-25th; and Memphis, Sept. 29th-30th.

TOBACCO FERTILIZER RECOMMENDATIONS FOR SOUTH ATLANTIC STATES

(Continued from page 14)

B. Sources of Plant Food

(1) *Nitrogen*—One-third of the nitrogen should be derived from high grade organic materials of plant or animal origin; one-third from materials supplying nitrogen in the nitrate form; and one-third from standard inorganic sources of nitrogen. (Fertilizers that are claimed to be made according to the recommended formulas should contain not less than one-third of the total nitrogen in organic form and not less than one-fourth of the nitrogen should be water insoluble). For the purpose of these recommendations, urea is considered the equivalent of an inorganic source of nitrogen.

(2) *Phosphoric Acid*—To be derived from any source of available phosphoric acid, provided that the available calcium in the mixture shall conform to the requirements of Subsection (7) of Section B.

(3) *Potash*—To be derived from any source of available potash, provided the chlorine content of the mixed fertilizers so compounded does not exceed two per cent, except that in case of soils where the pH is above 5.6, the maximum may be three per cent. Where it is desired to apply additional side dressings of potash, the sulfate is the most suitable form available for the purpose. If tobacco by-products are used as a source of potash, these must be sterilized to kill such disease organisms as might be present.

(4) *Magnesia*—It is recommended that fertilizers carry two per cent magnesia (MgO), at least one-half of which shall be derived from water soluble materials, or shall be water soluble in the mixed fertilizer.

(5) *Chlorine*—Available experimental data from bright tobacco sections of Virginia, North Carolina, South Carolina, Georgia and Florida show that a small quantity of chlorine in the tobacco fertilizer increases the acre value of the crop. Experiments have shown, however, that an excessive amount of chlorine in fertilizers used for tobacco injures its growth and reduces quality, producing a thick, brittle leaf, which when cured becomes thin, soggy and dull in color. It also has an unfavorable effect upon the burning quality of the cured leaf. It is recommended, therefore, that fertilizers should be compounded in such proportions that the fertilizer mixtures shall contain two per cent chlorine. Where the pH of the soil is above 5.6, the maximum may be 3 per cent.

(6) *Sulphur*—Sulphur is essential in bright tobacco fertilizers, but is usually contained in sufficient quantities in the materials recommended for compounding the fertilizers suggested by this conference. Materials containing excessive amounts of soluble SO_3 should be avoided in compounding bright tobacco fertilizers.

(7) *Calcium* is an essential element in tobacco production; and since fertilizers compounded with high analyses materials are sometimes low in calcium, it is recommended that tobacco fertilizers carry in an available form a minimum of six per cent of calcium oxide (CaO) equivalent.

C. Neutral Fertilizers

If neutral fertilizers are to be produced, it is suggested that the neutralizing agent be dolomitic limestone, as this material not only neutralizes but carries magnesia (MgO) and calcium (CaO), which are important plant nutrients. Basic fertilizers for bright tobacco are not recommended for general use.

(Continued on page 24)

See Page 4

Fertilizers for Plant Beds

Injury due to excess of chlorine has been widely observed in tobacco plant beds. Since fertilizers are applied to plant beds in relatively large quantities, even a small per cent of chlorine in the fertilizers may cause plant bed injury. It is, therefore, recommended that only such materials as are practically free of chlorides be used for making plant bed fertilizers, and that the fertilizer contain 6 per cent nitrogen, 9 per cent phosphoric acid, and 3 per cent potash applied at the rate of 1 pound to the square yard. The addition of one per cent available magnesia (MgO) will be beneficial in certain cases and its inclusion is generally to be recommended. In compounding this fertilizer, it is recommended that ¼ of the nitrogen be derived from nitrates, ¼ from natural organics, and ½ from standard inorganic sources, and that the fertilizer be free of chlorine.

CRUM JOINS UNION POTASH

The southern sales organization of the Union Potash & Chemical Co. has added Mr. H. M. Crum to their staff. Mr. Crum is well known in the fertilizer industry, with which he has been connected for many years, particularly in the tobacco belt of the Carolinas. He will make his territory in the states of North and South Carolina, with headquarters at 107 Shepherd St., Raleigh, N. C.

A CRITIQUE OF FIELD EXPERIMENTS

(Continued from page 11)

of such data; it may be foreseen that the difference will "not reach significance." But a practiced experimenter, who knows that he can trust his own work, and who is certain that he has not failed to make proper allowance for known circumstances that have affected the yields (gappy stand, bird damage, etc.) takes such data as they come. The marked jump from the first point to the second, the no less marked drop from the second point to the third, and the moderate rise from the third point to the fourth are not ascribable to change error (good work always presupposed). The yields indicated by these points in each case are *bona fide* expressions of the original reaction-strengths of the four closed mass-action systems plus the additional strengths contributed by the different treatments. The reality of the values of these indicated strengths, as certified by the weigh-scales, is therefore not open to valid statistical questioning by any method known to this writer.

Since the agrobiologically informed experimenter is *a priori* disposed to accept his results at their face value, he proceeds, as usual, to find a position on the yield diagram where the lines joining the four yield points of the RF experiment transect the fewest curves. The four points then fall respectively on curves 18.8, 20.4, 17.3 and 18.4. The average is 18.6 and the indicated normal yield curve for this field is 18.6 x 2 = 37.2. The average deviation from the normal is 0.8 ton, which is not nearly so terrifying as the statistically deduced significant difference of 5.9 tons.* The indicated normal curve is still steeply rising, and the indicated limit of yield is still distant by 5.2 tons.

All this, of course, is predicated on the assumption that the experimental field, *as a whole*, is a fair sample of the larger area it is supposed to represent; *i.e.*, it is supposed that adjacent sets of plots will be like those in the experimental field and vary within the same limits, which may or not be the case. It is axiomatic among experienced agriculturists that a field experiment with a plant nutrient is stringently valid only for the ground on which it stands. But since the agronomist must base his agronomic arrangements on probability of some sort, he has to look for probability where it is most likely to be found, and it is more surely to be found in consideration flowing out of the three major principles of quantitative plant biology than in the artificial structure erected by statisticians in disregard of elementary biological facts.

On these grounds both the use and the teaching of current statistical methods for the evaluation of field experiments with a plant nutrient are to be viewed askance. For practical use

* Ascribing such a difference to error amounts to slandering the careful operator.

they may be harmful in that they may cheat the plantation agronomist out of a visibly obtainable increase of yield by persuading him that the increase is unreal. In all the three Mauritian experiments here presented, there were increases that could hardly be ascribed to operative error; whether these increases were or were not profitable would depend on local costs and prices, and that matter is beside the point. The point here is that where a competent operator sees an increase on which a statistical analysis would throw cold water but which has an obvious cash value, he will be agrobiologically warranted to take the cash and let the statistical significance go.

A hardly less serious objection lies against the teaching of these methods to agricultural students who are not well grounded in quantitative plant biology. Any indoctrination of such students with the idea that the interaction of plants and the factors of their growth is ruled by chance rather than by perfectly definite natural law tends to keep plant biology in general and plant culture in particular in an atmosphere of foggy empiricism. The writer has often heard it said that "plant culture is not a science and never will be." But it is a fact that plant culture *is* a science, and is moreover an exact science, in that replication of a definite condition always produces the same definite quantitative result. In this sense the chemist and the physicist have "nothing on" the plant culturist who knows his agrobiology. The grower of plants will have difficulty enough in applying the laws that rule his science, and it may well be insisted that these difficulties be not added to by factitious and baseless irrelevancies. *Caveat statisticus.*

SYMPOSIUM ON PHOSPHATES

(Continued from page 7)

velopment. Phosphates may be used to contribute to the value of food products either by direct addition of appropriate salts solely for that purpose, or through the use of phosphate compounds in intermediate products such as baking powder.

The industrial importance of phosphates has increased rapidly in recent years. Uses cover widely divergent fields which have been greatly extended by the commercial development of the series of compounds classed as polyphosphates. Both orth- and poly-phosphates are used extensively as detergents. References to the drilling of oil wells, deflocculation of clay, and dispersion of textile dyes may be found in the long list of unusual applications.

Phosphates in Water Conditioning

Charles Schwartz and C. J. Munter, Hall Laboratories, Inc., Pittsburgh, Pa.

The properties of the ortho- and pyro-phosphates and of the phosphate glasses, such as the so-called "sodium hexametaphosphate," which render each of these types useful for different functions in the conditioning of water are discussed, with particular emphasis upon behavior with respect to hardness in water, dispersing effect upon suspended particles, stabilization of supersaturation, and pH.

Orthophosphate softens water by precipitation of very slightly soluble compounds; phosphates of the glassy type form soluble complexes with both calcium and magnesium; pyrophosphate forms complexes with magnesium but to a considerably lesser extent with calcium. Pyrophosphate and the glassy phosphates are powerful dispersing agents, while orthophosphate, aside from the behavior of trisodium orthophosphate as an alkali, is not. The "molecularly dehydrated" phosphates possess to varying degrees the ability to inhibit the precipitation of such slightly soluble substances as calcium carbonate, even when used in concentrations of only a few parts per million. Ortho- and pyro-phosphate behave as buffer salts; the glassy phosphates form a continuous series from the substantially neutral, nonbuffering "hexametaphosphate" to more alkaline glasses with higher Na_2O and lower P_2O_5 content.

Against the background of their properties, the application of the phosphates is discussed with respect to such uses as water-conditioning in the generation of steam, stabilization and control of corrosion in industrial and municipal water supplies, laundering, textile processing, mechanical dish and bottle washing, and domestic cleaning operations.

BUYERS' GUIDE

A CLASSIFIED INDEX TO ALL THE ADVERTISERS IN "THE AMERICAN FERTILIZER"

This list contains representative concerns in the Commercial Fertilizer Industry, Including fertilizer manufacturers, machinery and equipment manufacturers, dealers in and manufacturers of commercial fertilizer materials and supplies, brokers, chemists, etc.
For Alphabetical List of Advertisers, see page 33.

A Classified Index to Advertisers in "The American Fertilizer"

BUYERS' GUIDE

For an Alphabetical List of all the Advertisers, see page 33

BUCKETS—For Hoists, Cranes, etc., Clam Shell, Orange Peel, Drag line, Special; Electrically Operated and Multi Power
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.

BURNERS—Sulphur
Chemical Construction Corp., New York City.

BURNERS—Oil
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CABLEWAYS
Hayward Company, The, New York City.

CARBONATE OF AMMONIA
American Agricultural Chemical Co., New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CARS—For Moving Materials
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CARTS—Fertilizer, Standard and Roller Bearing
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

CASTINGS—Acid Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.

CASTINGS—Iron and Steel
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CEMENT—Acid-Proof
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

CHAIN DRIVES—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAINS AND SPROCKETS
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHAMBERS—Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CHEMICAL APPARATUS
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

CHEMICALS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., E. I., Wilmington, Del.

CHEMICALS—Continued
Huber & Company, New York City.
Phosphate Mining Co., The, New York City.
Wellmann, William E., Baltimore, Md.

CHEMICAL PLANT CONSTRUCTION
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CHEMISTS AND ASSAYERS
Gascoyne & Co., Baltimore, Md.
Shuey & Company, Inc., Savannah, Ga.
Stillwell & Gladding, New York City.
Wiley & Company, Baltimore, Md.

CLUTCHES
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

CONCENTRATORS—Sulphuric Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.

CONDITIONERS AND FILLERS
American Limestone Co., Knoxville, Tenn.
Dickerson Co., The, Philadelphia, Pa.
Phosphate Mining Co., The, New York City.

CONTACT ACID PLANTS
Chemical Construction Corp., New York City.

COPPER SULPHATE
Tennessee Corporation, Atlanta, Ga.

COTTONSEED PRODUCTS
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

CRANES AND DERRICKS
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link-Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.
Sackett & Sons Co., The A. J., Baltimore, Md.

CYANAMID
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Jett, Joseph C., Norfolk, Va.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

DENS—Superphosphate
Chemical Construction Corp., New York City.
Stedman's Foundry and Mach. Works, Aurora, Ind.

A Classified Index to Advertisers in "The American Fertilizer"

BUYERS' GUIDE

For an Alphabetical List of all the Advertisers, see page 33

DISINTEGRATORS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DRYERS—Direct Heat
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.

DRIVES—Electric
Link-Belt Company, Philadelphia, Chicago.

DUMP CARS
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

DUST COLLECTING SYSTEMS
Sackett & Sons Co., The A. J., Baltimore, Md.

ELECTRIC MOTORS AND APPLIANCES
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

ELEVATORS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ELEVATORS AND CONVEYORS—Portable
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

ENGINEERS—Chemical and Industrial
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

ENGINES—Steam
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

EXCAVATORS AND DREDGES—Drag Line and Cableway
Hayward Company, The, New York City.
Link-Belt Company, Philadelphia, Chicago.
Link Belt Speeder Corp., Chicago, Ill., and Cedar Rapids, Iowa.

FERTILIZER MANUFACTURERS
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Farmers Fertilizer Co., Columbus, Ohio
International Agricultural Corporation, Chicago, Ill.
Phosphate Mining Co., The, New York City.
U. S. Phosphoric Products Division, Tennessee Corp., Tampa, Fla.

FISH SCRAP AND OIL
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
Jett, Joseph C., Norfolk, Va.
McIver & Son, Alex. M., Charleston, S. C.
Taylor, Henry L., Wilmington, N. C.
Wellmann, William E., Baltimore, Md.

FOUNDERS AND MACHINISTS
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GARBAGE TANKAGE
Wellmann, William E., Baltimore, Md.

GEARS—Machine Moulded and Cut
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

GEARS—Silent
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

GELATINE AND GLUE
American Agricultural Chemical Co., New York City.

GUANO
Baker & Bro., H. J., New York City.

HOISTS—Electric, Floor and Cage Operated, Portable
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.

HOPPERS
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

IMPORTERS, EXPORTERS
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

IRON SULPHATE
Tennessee Corporation, Atlanta, Ga.

INSECTICIDES
American Agricultural Chemical Co., New York City.

LACING—Belt
Sackett & Sons Co., The A. J., Baltimore, Md.

LIMESTONE
American Agricultural Chemical Co., New York City.
American Limestone Co., Knoxville, Tenn.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Wellmann, William E., Baltimore, Md.

LOADERS—Car and Wagon, for Fertilizers
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Acid Making
Atlanta Utility Works, East Point, Ga.
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.
Duriron Co., Inc., The, Dayton, Ohio.
Fairlie, Andrew M., Atlanta, Ga.
Monarch Mfg. Works, Inc., Philadelphia, Pa.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Coal and Ash Handling
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.

MACHINERY—Elevating and Conveying
Atlanta Utility Works, East Point, Ga.
Hayward Company, The, New York City.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

A Classified Index to Advertisers in "The American Fertilizer"

BUYERS' GUIDE

For an Alphabetical List of all the Advertisers, see page 33

MACHINERY—Grinding and Pulverizing
Atlanta Utility Works, East Point, Ga.
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Power Transmission
Jeffrey Manufacturing Co., The, Columbus, Ohio.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MACHINERY—Pumping
Atlanta Utility Works, East Point, Ga.
Duriron Co., Inc., The, Dayton, Ohio.

MACHINERY—Tankage and Fish Scrap
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MAGNETS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

MANGANESE SULPHATE
McIver & Son, Alex. M., Charleston, S. C.
Tennessee Corporation, Atlanta, Ga.

MIXERS
Atlanta Utility Works, East Point, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

NITRATE OF SODA
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Barrett Company, The, New York City.
Bradley & Baker, New York City.
Chilean Nitrate Sales Corp., New York City.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

NITRATE OVENS AND APPARATUS
Chemical Construction Corp., New York City.

NITROGEN SOLUTIONS
Barrett Company, The, New York City

NITROGENOUS ORGANIC MATERIAL
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
DuPont de Nemours & Co., Wilmington, Del.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
McIver & Son, Alex. M., Charleston, S. C.
Smith-Rowland Co., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

NOZZLES—Spray
Monarch Mfg. Works, Philadelphia, Pa.

PACKING—For Acid Towers
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Chemical Construction Corp., New York City.

PANS AND POTS
Stedman's Foundry and Mach. Works, Aurora, Ind.

PHOSPHATE MINING PLANTS
Chemical Construction Corp., New York City.

PHOSPHATE ROCK
American Agricultural Chemical Co., New York City.
American Cyanamid Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Charleston Mining Co., Inc., Richmond, Va.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
Phosphate Mining Co., The, New York City.
Ruhm, H. D., Mount Pleasant, Tenn.
Schmaltz, Jos. H., Chicago, Ill.
Southern Phosphate Corp., Baltimore, Md.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

PIPE—Acid Resisting
Duriron Co., Inc., The, Dayton, Ohio.

PIPES—Chemical Stoneware
Chemical Construction Corp., New York City.

PIPES—Wooden
Stedman's Foundry and Mach. Works, Aurora, Ind.

PLANT CONSTRUCTION—Fertilizer and Acid
Chemical Construction Corp., New York City.
Fairlie, Andrew M., Atlanta, Ga.
Sackett & Sons Co., The A. J., Baltimore, Md.

POTASH SALTS—Dealers and Brokers
American Agricultural Chemical Co., New York City.
Armour Fertilizer Works, Atlanta, Ga.
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., H. J., New York City.
Bradley & Baker, New York City.
Huber & Company, New York City.
International Agricultural Corporation, Chicago, Ill.
Jett, Joseph C., Norfolk, Va.
Schmaltz, Jos. H., Chicago, Ill.
Taylor, Henry L., Wilmington, Del.
Wellmann, William E., Baltimore, Md.

POTASH SALTS—Manufacturers
American Potash and Chem. Corp., New York City.
Potash Co. of America, New York City.
United States Potash Co., New York City.

PULLEYS AND HANGERS
Atlanta Utility Works, East Point, Ga.
Link-Belt Company, Philadelphia, Chicago.
Sackett & Sons Co., The A. J., Baltimore, Md.
Stedman's Foundry and Mach. Works, Aurora, Ind.

PUMPS—Acid-Resisting
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.
Duriron Co., Inc., The, Dayton, Ohio.
Monarch Mfg. Works, Inc., Philadelphia, Pa.

PYRITES—Brokers
Ashcraft-Wilkinson Co., Atlanta, Ga.
Baker & Bro., New York City.
Jett, Joseph C., Norfolk, Va.
Wellmann, William E., Baltimore, Md.

QUARTZ
Charlotte Chem. Laboratories, Inc., Charlotte, N. C.

RINGS—Sulphuric Acid Tower
Chemical Construction Corp., New York City.

ROUGH AMMONIATES
Bradley & Baker, New York City.
Schmaltz, Jos. H., Chicago, Ill.
Wellmann, William E., Baltimore, Md.

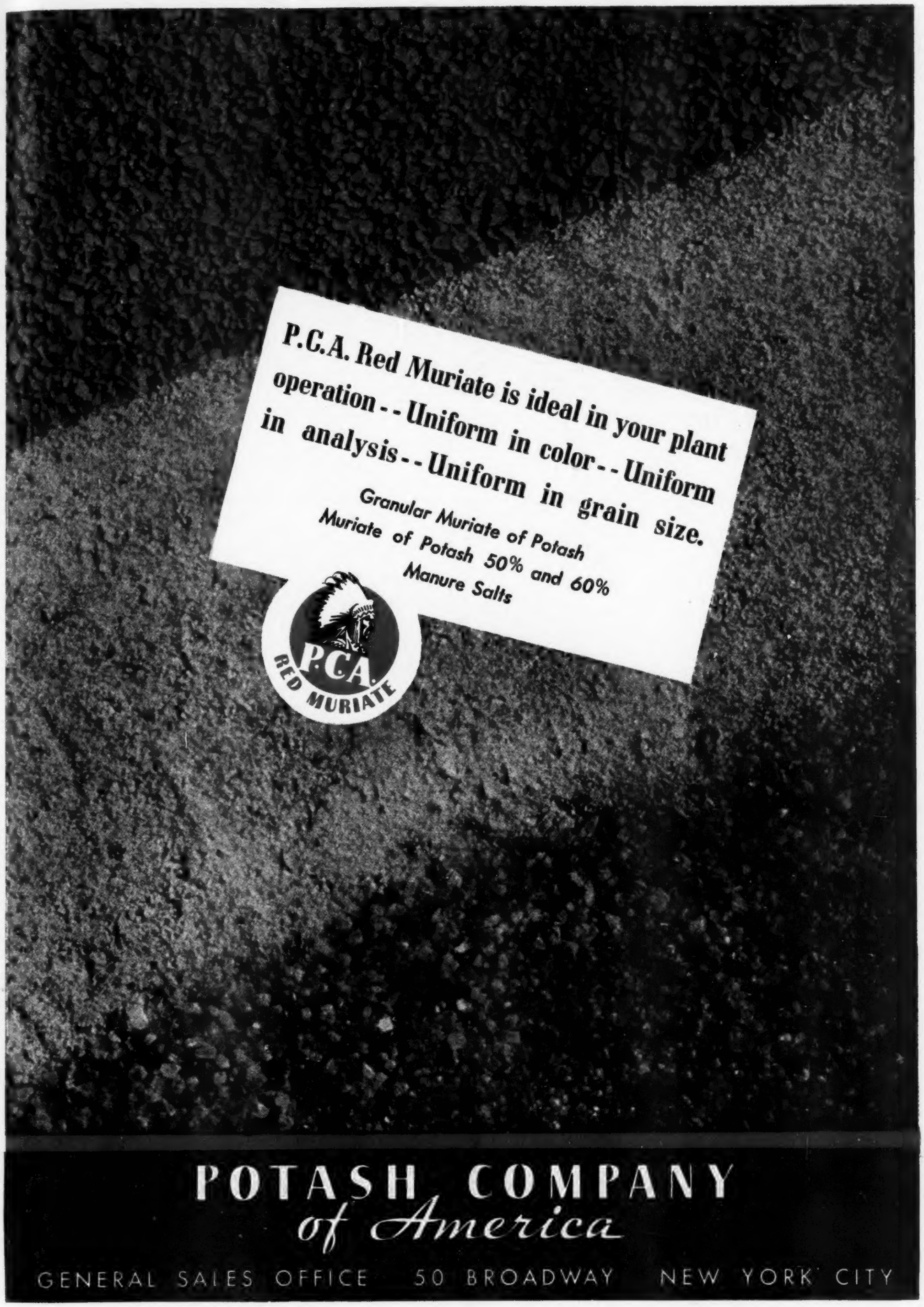
A Classified Index to Advertisers in "The American Fertilizer"

BUYERS' GUIDE

For an Alphabetical List of all the Advertisers, see page 33

ALPHABETICAL LIST OF ADVERTISERS

For Classified Index, see pages 28 to 32, inclusive


P.C.A. Red Muriate is ideal in your plant operation - - Uniform in color - - Uniform in analysis - - Uniform in grain size.
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Muriate of Potash 50% and 60%
Manure Salts
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